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L. O. HOWARD, Entomologist and Chief of Bureau.

INSECT DAMAGE TO STANDING TIMBER IN THE NATIONAL PARKS.

BY

A. D. HOPKINS,
In Charge of Forest Insect Investigations.

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United States Department of Agriculture,

BUREAU OF ENTOMOLOGY.

L. O. HOWARD, Entomologist and Chief of Bureau.

INSECT DAMAGE TO STANDING TIMBER IN THE NATIONAL PARKS. [1]

By A. D. HOPKINS,
In Charge of Forest Insect Investigations.

CHARACTER OF THE DAMAGE.

The damage by insects to the living trees of the forests and ornamental grounds of the national parks consists of injuries to the foliage, branches, or the entire tree which mar or destroy their attractive, educational, and historic features and diminish or destroy their commercial value.

Throughout the forests of the Rocky Mountains and Pacific slope, including the national parks, a large percentage of the timber has died during the past half century. The old standing and fallen dead trees, the red foliage of those that died last year, and the fading tops of those now dying bear evidence of the work of insects and are conspicuous examples of a great waste of forest resources. In some localities a few scattering trees die each year within a township or section; in others, clumps of trees or whole forests die during a single year.

The conifers, which are the predominating trees of this western part of the country, are subject to a high death rate from insect attacks. The pines, the spruces, the Douglas fir, the balsam firs, the hemlocks, the cedars, and the Sequoias (redwoods) have each at least one destructive enemy.

In the fall, spring, and early summer the dying and recently dead trees are conspicuous on account of their fading, yellowish-red, and reddish-brown foilage, as if injured by fire. When they are in large patches, or extend over a considerable area, their death is often attributed by the casual observer to forest fires.

[1] This paper was read by the author at a conference of national park superintendents held under the auspices of the Secretary of the Interior, September 11–12, 1911, and is embodied in the proceedings of the meeting issued by the Interior Department.

EXTENT OF THE DAMAGE.

The extent of the damage to the forests by insects through the accumulation of dead timber and the dying of matured trees over large areas is vastly greater than the general observer would suppose. In fact, the dead and fallen timber is so common in all forests that it has heretofore been recognized as a natural and inevitable condition. Large areas of insect-killed timber have been charged to fire without further thought or examination to determine the real cause. Fallen timber has been attributed to storms, and scattering dead trees to old age.

During the present year a reconnaissance was made of typical sections in one of the national forests, where there was no evidence that destructive forest fires had occurred during the past 20 years. It was found that the standing and fallen dead yellow pine that had died within that period amounted in board feet to nearly half as much as that which was then living, and of the sugar pine and Douglas fir there was one-fourth as much dead as was then living, and every dead tree examined in the estimate showed evidence that it had been killed by insects.

In the Black Hills National Forest of South Dakota over one-half of the timber died within a period of about 10 years. In Oregon and Montana nearly all of the larger pine died within a few years on areas of a few hundred acres to 100,000 acres or more. These together with many other examples of extensive dying of timber have been investigated and found to be caused primarily by insects. Investigations have also demonstrated beyond question that a vast amount of timber is killed by insects every year within the forested areas of the Rocky Mountain and Pacific Coast regions. Furthermore, the accumulation of this dead timber and fallen débris is a menace to the living, because it furnishes fuel for destructive forest fires. The losses from insect depredations are thus augmented by fires.

The extent of damage to the forest and other trees of the national parks has not been estimated and, with the exception of investigations conducted in the Yosemite and Glacier Parks, we do not have much direct information as to the damage already done. It is plain to us, however, that the general conditions are not different from those which prevail throughout the regions in which the parks are located and in which the destructive species of insects are known to occur.

The amount of damage in the parks must be considered not only on the basis of the commercial value of the forest resources, but on that of the æsthetic and educational value of the virgin forest with its typical examples of tree species.

The loss of a section of the forest which forms the attractive feature in the landscape, or is the only remaining example of the origi-

nal type of forest growth of that region, is far greater than that represented by the commercial value of the timber; as is also the loss of notable veterans and giants of the different species. These old forests and old trees are at present one of the attractive and instructive features of the timbered areas of some of the national parks, and if they are protected from their insect and other enemies they will be even more attractive features in coming centuries. Under present conditions, these old trees of the virgin forest are in greater danger of being killed by insects than are the younger trees. Indeed, many of them have been killed within recent years.

The three giant sugar pines on the trail from Wawona to Glacier Point and the Yosemite Valley are examples. Two of them were dead and the other was dying when I saw them in June, 1904, and there was conclusive evidence that their death was caused by the mountain pine beetle. The veteran sugar pine, known as "Uncle Tom," was being attacked at that time by the same species of beetle, and I am informed that it died the following year. The loss of these four giants of the species is irreparable.

The Sequoias are supposed to be immune to the attack of insects, but they are not. They are more resistant than other species, and that is one reason they have lived so long. However, each species has a barkbeetle enemy which, under favorable conditions, is capable of killing the largest and finest specimens. I saw one of the large redwoods in the vicinity of Eureka, Cal., that had been killed by its barkbeetle enemy, and when in the Mariposa Grove, in 1904, I discovered the barkbeetle enemy of the big tree in the living bark of a storm-broken limb.

THE PRINCIPAL DEPREDATORS.

The mere mention of the names of the thousands of species of insects, each of which causes some peculiar injury during the life of the different tree species, would occupy more space than is allotted for this paper. Therefore we must consider the more important of those which are directly responsible for the death of the trees.

The little genus of Dendroctonus beetles, or tree-killing beetles, is represented in the Rocky Mountain and Pacific Slope regions by a few species which are more destructive to the conifers of western North America than all other forest insects combined. They are a constant menace to the pine, spruce, and Douglas fir of the national parks. They are certain to be present in every park in which there are forests of their host trees, and have doubtless caused far greater damage than the park officials have realized.

The species, in the order of their destructiveness, are the mountain pine beetle, the western pine beetle, the Engelmann spruce beetle, the

Jeffrey pine beetle, and the red turpentine beetle. All but the Jeffrey pine beetle of the Sierras are common to the northern Rocky Mountains and the Pacific Slope. Those common to the central and southern Rocky Mountains are the Black Hills beetle, the Engelmann spruce beetle, the Douglas fir beetle, and the red turpentine beetle. There are three other species common to the southern Rocky Mountains and northern Mexico which are of less importance in causing the death of trees.

These insects are small, stout, black to reddish-brown beetles, ranging in length from about 2 mm. to 9 mm., or 0.08 to 0.36 of an inch. They fly in the period from April to October and attack the main trunks of the living healthy trees by boring into the bark and excavating long winding or nearly straight egg galleries between the bark and wood. In this manner they completely girdle and thus cause the death of their victims. As soon as the bark begins to die the eggs deposited by the beetles hatch and the young grubs, or larval forms, complete the destruction of the inner bark. All of the broods develop into the adult stage within a year and emerge from the bark to fly in search of new victims. Each species has its peculiar habits in the choice of host trees, methods of attack, and period of development.

THE MOUNTAIN PINE BEETLE.

The mountain pine beetle attacks the mountain or silver pine, sugar pine, western yellow pine, lodgepole pine, and evidently all other pines of the northern Rocky Mountains and the Pacific slope. The adult beetles fly in the period from July to October, inclusive. When abundant they concentrate their attack on clumps and patches of trees. Their long, nearly straight egg galleries and radiating larval mines soon kill the bark on the main trunks, but the foliage of the infested trees remains green and apparently healthy until the following May and June. It then begins to change to a pale green and later to yellowish and brown. By the time all of the foliage is dead, about the 1st of July, the overwintered broods of beetles begin to emerge. By the middle of August most of them are out of the dead trees and have entered the living ones.

This is by far the most destructive insect enemy of the pine within its range, and under present conditions is a constant menace to the forests of matured or merchantable-sized timber. It can be controlled by felling the infested trees and by removing the infested bark from the main trunks without burning the bark or tops. This work must be done during the period between the 1st of October and the 1st of July to destroy the broods of the beetle before they emerge. Whenever the timber can be utilized the product will pay all expenses. If it has no commercial value it will cost on an average

50 cents a tree for the required treatment. After an outbreak is under control the living timber can be easily protected from further depredations by giving prompt attention to the felling and barking of any clumps of dying trees found during May and June. Rangers or fire patrolmen can be instructed so that they can do this and anything else that is required to maintain control.

THE WESTERN PINE BEETLE.

The western pine beetle attacks the western yellow pine, the sugar pine, and the Jeffrey pine. The beetles fly in late June to October, inclusive, and usually attack scattering individual trees, often selecting the larger and older examples. The adults excavate winding egg galleries between the inner living bark and the wood and transform to the adult stage in the outer bark. The beetles begin to fly and attack the trees in June and continue the attack until October or November. The first generation develops and emerges in August to November, and the second generation passes the winter in the trees that are killed by it in the summer and fall.

The foliage of the infested trees begins to fade and turn yellow in a few weeks after the trees are attacked by this beetle. The summer broods of the first generation leave the trees by the time the foliage is reddish brown, but the overwintered broods do not emerge until the following May and June, in some cases several months after the foliage is brown.

This species is next in importance to the mountain pine beetle as a destructive enemy of the pine, and the two species often combine in their attack. In this combined attack the western pine beetle is a secondary enemy of the trees because it follows the attack of the other species. When it is the primary enemy it is responsible for the death of a few scattering trees each year throughout the forest, which results in the accumulation of dead timber. In the aggregate, this accumulative loss is very extensive, involving, as it does, the largest and best trees.

The insect can be controlled and the living timber protected from its ravages by felling the infested trees during the period between the 1st of October and the 1st of June and removing the bark from the main trunks and burning it. It is necessary to burn the bark because the broods of this species transform in the outer bark. They are not destroyed by simply exposing the inner bark, as is the case with the mountain pine beetle.

THE JEFFREY PINE BEETLE.

The characteristic habits of the Jeffrey pine beetle are similar to those of the mountain pine beetle, and therefore it requires the same treatment.

THE DOUGLAS FIR BEETLE.

The Douglas fir beetle attacks the Douglas fir, the big-cone spruce, and the western larch. The beetles fly in April and May and enter the living bark on healthy trees and on trees that have been injured by fire and those that have been recently felled. In habits of attack and general characteristics the Douglas fir beetle is similar to the mountain pine beetle, except that the former begins to fly earlier in the season and the foliage of the trees infested begins to die in the fall. It is very destructive to the Douglas fir throughout the Rocky Mountain region from British Columbia to Mexico, but is much less so on the Pacific slope, especially toward the coast. It can be controlled by felling the infested trees during the period between the 1st of September and the 1st to middle of the following April and removing the infested bark from the trunks without burning.

THE RED TURPENTINE BEETLE.

The red turpentine beetle is the largest species of the genus Dendroctonus. It begins to fly in April and is active until October and November. It attacks the pine and rarely the spruce. As a rule it confines its operation to the base or basal portion of the trunks. While its normal habit is to breed in the bark of stumps and logs of newly felled trees, it often infests the bark on healthy trees. It rarely kills a tree, but is the cause of a large percentage of the basal wounds known as "cat faces" and fire wounds, so commonly met with in the pine. This is a far more difficult species to control than the others because it breeds in the stumps of felled trees and the base of those killed by the other species or by fire. Valuable individual trees can be protected by cutting the beetles out of the bark as soon as their presence is indicated by masses of exuding resin mixed with reddish boring dust.

Wherever there are continued lumbering operations the red turpentine beetle confines its attack to the stumps, but in the national parks and private grounds where a limited amount of timber is cut, or where the ravages of the mountain pine and western pine beetles have been controlled, it is likely to cause more or less extensive damage to the living timber for a year or two after.

In combating the other beetles in the national parks, care should be taken to remove the bark from the stumps whenever they are found to be infested with this pest.

THE ENGELMANN SPRUCE BEETLE.

The Engelmann spruce beetle attacks the Engelmann spruce, blue spruce, and any other species of spruce found within its range, but

does not attack the pine, Douglas fir, or balsam fir. It flies in the period from June to August and attacks the bark of the main trunks of the older or matured trees. Its habits are similar to those of the mountain pine beetle, except that it flies earlier in the spring. When the trees begin to die the needles fade to a pale green and fall before they change to yellow or brown, but the bare twigs present a grayish-brown appearance. The infested trees are easily located in the fall and early spring by the fallen needles and the bare twigs of the tops.

This species occurs from British Columbia to Mexico and at times is very destructive to the Engelmann spruce forests. It can be controlled by felling the infested trees and removing the bark from the main trunks during the period beginning with the 1st of October and ending by the middle to last of May.

THE BLACK HILLS BEETLE.

The Black Hills beetle is by far the most destructive insect enemy of the pine of the central and southern Rocky Mountains and the Black Hills of South Dakota. Its habits are similar to those of the mountain pine beetle, and the same methods are adopted for its control.

FAVORABLE CONDITIONS FOR THE BEETLES.

There are certain conditions in the administered as well as in the natural forests which contribute to the multiplication and destructive work of these Dendroctonus beetles. One of the most favorable conditions is an extensive forest of matured and old trees of pine or spruce, because in the beginning of an invasion such trees are more often the first to be attacked and killed. Trees in such a forest injured by lightning or storms often form centers of infestation in which the beetles increase to sufficient numbers to enable them to kill a few trees, and then the invasion is started, year after year increasing in force until a large percentage or all of the old timber is killed. The beetles then attack the young trees and often waste their energies on saplings, in which the broods fail to develop.

Drought.—It is a common belief that severe droughts weaken the trees and thus contribute to favorable conditions for the attack of the beetles. We have made a very thorough investigation of this subject and are led to conclude that exceptionally dry seasons are more unfavorable for the development of the beetles than are moderately humid ones, and that, therefore, droughts do not contribute to their multiplication.

Forest fires.—Forest fires contribute, to a limited extent, to the multiplication of certain species which breed in fire-scorched trees, but as a rule forest fires kill more beetles than they protect.

Commercial cutting.—Commercial cutting of timber may contribute to the multiplication of certain species which breed in the stumps and tops, but if the cutting is continuous the insects confine their attack to the cut-over areas and do not invade the living timber. Sporadic summer cutting, however, is dangerous. The odor of the cut wood attracts the flying beetles to the locality. This contributes to their concentration, and when the cutting is stopped they invade the living timber.

Secondary enemies.—The secondary enemies of the trees consist of numerous species which attack the bark and wood as soon as the trees become weakened and are dying from other causes. The Dendroctonus beetles are the primary enemies or leaders in the attack. The secondary enemies are, to a certain extent, their allies, and when very abundant may contribute to favorable conditions for rapid advance in the destructive movement, but more often they are dependents and scavengers, merely utilizing the dead and waste material. With rare exceptions these secondary enemies are not capable of killing trees on their own account.

UNFAVORABLE CONDITIONS FOR THE BEETLES.

The unfavorable conditions for the destructive work of these Dendroctonus beetles are to be found in administered forests where the ripe or matured timber is utilized and where the young timber is protected by the prompt disposal, during the fall, winter, and spring months, of any clumps of dying trees.

In other words, systematic forest management based on a knowledge of the principles of silviculture and forest entomology will soon present conditions so unfavorable for the Dendroctonus beetles that they can no longer exist as agents of destruction and waste.

The natural enemies of the beetles serve as a repelling force against the progressive development of an invasion. Indeed, they are among the principal factors which have prevented the extermination of certain of the more important forest-tree species. These natural enemies consist of parasites and predatory insects, which feed on all stages of the barkbeetles, and birds, which feed on the adults and young of the barkbeetles. Were it not for the fact that birds also feed on the predatory and parasitic insect enemies of the barkbeetles, and that such birds are limited in numbers, they might render the great service that is so commonly credited to them.

Insect diseases in the form of epidemics sometimes serve to bring an invasion under complete control, and unfavorable climatic conditions have been known to exterminate a species of Dendroctonus beetles within an area of thousands of square miles.

Therefore, although under natural conditions successive generations of the older trees are killed by their insect enemies, these in

turn are checked or repelled by natural means, so that generations of younger trees take the place of their ancestors, and the forest as such is perpetuated.

Natural control the most expensive.—In the national parks, national forests, and private forests where the resources have a commercial value this natural control of the insect depredators on the timber is the most expensive and wasteful. Our friends, the enemies of the beetles, can not be depended upon to operate for the best interests of the Federal or private owner. They can, however, be made to render efficient service as the allies of the owner in an aggressive warfare by him against the invaders. In this capacity they are indispensable in the defense against renewed attacks and in the maintenance of conditions which will insure the future protection of the living timber.

GENERAL METHODS OF CONTROL.

It is through a knowledge of the habits and seasonal history of the various species of depredating insects, and the various complex factors operating for and against them, that forest entomologists are enabled to advise methods of procedure in practical control operations either to reduce or eliminate the favorable conditions for the multiplication of the beetles or to promote and utilize the factors that are unfavorable for their existence.

It is also through a knowledge of the characteristic evidences of their presence in the living and dying trees that we are enabled to give instructions to an experienced timber cruiser, forest ranger, or fire patrolman which will enable him readily to detect an infestation and report upon its character and extent.

Experiments with and demonstrations of methods of control have furnished up-to-date information on the essential requirements in conducting active control operations, which enables us to advise the most economical and effectual method to be adopted for each species of beetle, each species of tree, and each locality where an infestation prevails.

Therefore, if the symptoms are accurately described and information is furnished as to the local facilities for utilizing the infested timber or for treatment at direct expense, specific recommendations for successful control can be made without an examination by an expert.

The presence in any national park of quantities of dying pine, spruce, or Douglas fir that has not been caused by recent fires is evidence of the presence and destructive work of one or more species of the Dendroctonus beetles. An examination of the bark of the main trunks of some of the dying trees will usually furnish conclusive evidence, for if the trees are infested the characteristic work in the

bark, as illustrated in the bulletins of the Bureau of Entomology, will be easily recognized.

The next thing to do is to determine the extent of the infestation, the kind of trees involved, and the facilities for disposing of the timber by sale, free use, or direct expense. Then the superintendent should report the facts to an expert and ask for advice and recommendations. If he will then proceed without delay to dispose of the infestation according to instructions given him, success in checking or completely controlling the pest is almost certain to follow.

If, upon locating an infested area, it is found to extend beyond the park boundary into adjacent privately owned timber or the national forests, cooperation or at least concerted action is required, because an important center of infestation is a menace to the living timber within a radius of 10 to 20 miles.

If the timber of a national park is healthy and centers of infestation are found in adjacent forests within a radius of 10 to 20 miles, the park superintendent should notify the owners. If, for any reason, the owners can not dispose of the infestation the park officials should help do it just as they would help in fighting a fire that was threatening the park. In like manner the Federal and private owners of healthy timber adjacent to a park should help dispose of any extensive infestation in the park, because it may be more of a common menace than a forest fire.

If this policy of cooperation for the general good is adopted and the essential requirements for successful control are strictly adhered to for a few years by the officials of the national parks, the national forests, and the principal private owners, the damage to living timber in the parks and on adjacent lands will be reduced to a minimum, and ultimately thousands of dollars in commercial and æsthetic values will be saved for every dollar of public or private money expended.

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